A transient 2D PEMFC model to investigate cell performance and degradation

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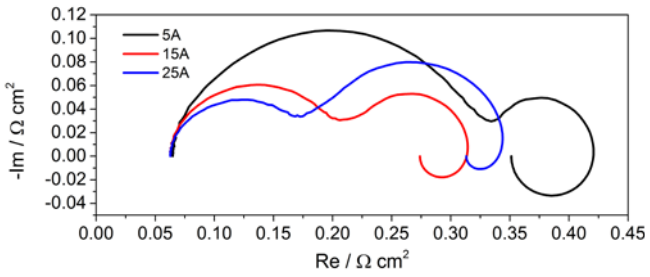
Polymer electrolyte membrane fuel cells (PEMFCs) are environmentally friendly alternatives to conventional energy conversion systems. However, performance degradation still poses a major challenge for this technology. A better understanding of the underlying mechanisms is crucial in order to be able to predict cell performance and durability. Detailed physical models allow identifying and investigating these mechanisms and represent important tools for optimization of cell performance and reduction of degradation.

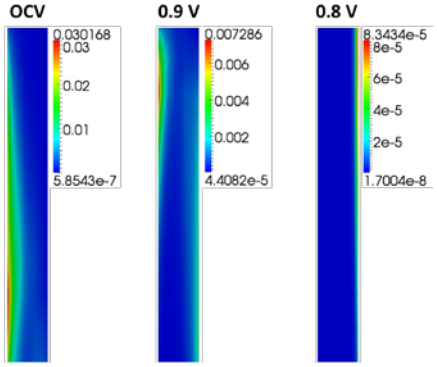
Here, we present a transient, two-dimensional single cell model for PEMFCs implemented in our in-house code NEOPARD-FC, which is based on the open-source framework DuMux [1]. The model is non-isothermal and includes electrochemistry, two-phase multi-component transport in the porous layers as well as water and gas permeation through the membrane.

Simulations of polarization curves and impedance spectra under various operating conditions are performed to validate the model. The validated model provides important insights on the local conditions within the cell which are often not accessible in experiments. The occurrence of heterogeneities of temperature, species concentrations, etc. is discussed. In particular, we focus on the water management, which plays an important role for cell performance.

The cell model also provides the basis to study degradation phenomena, since the local degradation rates depend on the local conditions within the cell. Simulations of membrane degradation by coupling the cell model with a chemical membrane degradation model are presented.



a) Simulated Impedance spectra for different current densities



b) Simulated rate of local SO3- loss / mol m^{-3} s^{-1} in the membrane for different cell voltages

References:

[1] B. Flemisch, M. Darcis, K. Erbertseder, B. Faigle, A. Lauser, K. Mosthaf, et al., Advances in Water Resources **34,** 1102–1112 (2011).